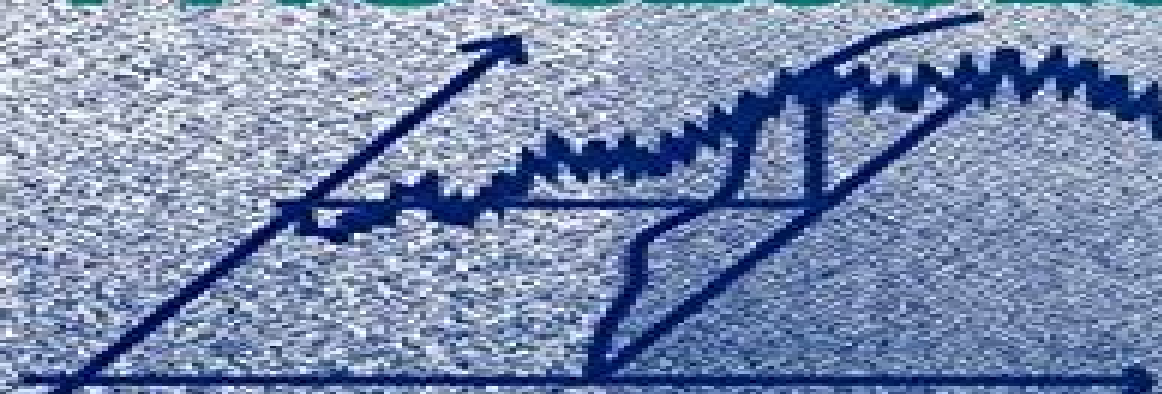


NUMERICAL METHODS FOR STOCHASTIC PROCESSES



Nicolas Bouleau
Dominique Lépingle

Wiley Series in Probability and Mathematical Statistics:
Applied Probability and Statistics Section

Numerical Methods For Stochastic Processes

D. Kannan,V. Lakshmikantham



Numerical Methods For Stochastic Processes:

Numerical Methods for Stochastic Processes Nicolas Bouleau, Dominique Lépingle, 1994-01-14 Gives greater rigor to numerical treatments of stochastic models Contains Monte Carlo and quasi Monte Carlo techniques simulation of major stochastic procedures deterministic methods adapted to Markovian problems and special problems related to stochastic integral and differential equations Simulation methods are given throughout the text as well as numerous exercises

Numerical Methods for Stochastic Partial Differential Equations with White Noise Zhongqiang Zhang, George Em Karniadakis, 2017-09-01 This book covers numerical methods for stochastic partial differential equations with white noise using the framework of Wong Zakai approximation The book begins with some motivational and background material in the introductory chapters and is divided into three parts Part I covers numerical stochastic ordinary differential equations Here the authors start with numerical methods for SDEs with delay using the Wong Zakai approximation and finite difference in time Part II covers temporal white noise Here the authors consider SPDEs as PDEs driven by white noise where discretization of white noise Brownian motion leads to PDEs with smooth noise which can then be treated by numerical methods for PDEs In this part recursive algorithms based on Wiener chaos expansion and stochastic collocation methods are presented for linear stochastic advection diffusion reaction equations In addition stochastic Euler equations are exploited as an application of stochastic collocation methods where a numerical comparison with other integration methods in random space is made Part III covers spatial white noise Here the authors discuss numerical methods for nonlinear elliptic equations as well as other equations with additive noise Numerical methods for SPDEs with multiplicative noise are also discussed using the Wiener chaos expansion method In addition some SPDEs driven by non Gaussian white noise are discussed and some model reduction methods based on Wick Malliavin calculus are presented for generalized polynomial chaos expansion methods Powerful techniques are provided for solving stochastic partial differential equations This book can be considered as self contained Necessary background knowledge is presented in the appendices Basic knowledge of probability theory and stochastic calculus is presented in Appendix A In Appendix B some semi analytical methods for SPDEs are presented In Appendix C an introduction to Gauss quadrature is provided In Appendix D all the conclusions which are needed for proofs are presented and in Appendix E a method to compute the convergence rate empirically is included In addition the authors provide a thorough review of the topics both theoretical and computational exercises in the book with practical discussion of the effectiveness of the methods Supporting Matlab files are made available to help illustrate some of the concepts further Bibliographic notes are included at the end of each chapter This book serves as a reference for graduate students and researchers in the mathematical sciences who would like to understand state of the art numerical methods for stochastic partial differential equations with white noise

Numerical Analysis of Stochastic Processes Wolf-Jürgen Beyn, Raphael Kruse, 2016-10-15 This textbook introduces into the art of analysing approximating and solving stochastic differential

equations Random number generation and monte carlo methods as well as convergence theorems and discretisation effects are discussed Apart from mathematical problems these equations occur in physical engineering and economic models e g due to a lack of knowledge of the underlying complex systems

Stochastic Processes: Modeling and Simulation D N Shanbhag,Calyampudi Radhakrishna Rao,2003-02-24 This sequel to volume 19 of Handbook on Statistics on Stochastic Processes Modelling and Simulation is concerned mainly with the theme of reviewing and in some cases unifying with new ideas the different lines of research and developments in stochastic processes of applied flavour This volume consists of 23 chapters addressing various topics in stochastic processes These include among others those on manufacturing systems random graphs reliability epidemic modelling self similar processes empirical processes time series models extreme value therapy applications of Markov chains modelling with Monte Carlo techniques and stochastic processes in subjects such as engineering telecommunications biology astronomy and chemistry particular with modelling simulation techniques and numerical methods concerned with stochastic processes The scope of the project involving this volume as well as volume 19 is already clarified in the preface of volume 19 The present volume completes the aim of the project and should serve as an aid to students teachers researchers and practitioners interested in applied stochastic processes

Numerical Solution of Stochastic Differential Equations with Jumps in Finance Eckhard Platen,Nicola Bruti-Liberati,2010-07-23 In financial and actuarial modeling and other areas of application stochastic differential equations with jumps have been employed to describe the dynamics of various state variables The numerical solution of such equations is more complex than that of those only driven by Wiener processes described in Kloeden Platen Numerical Solution of Stochastic Differential Equations 1992 The present monograph builds on the above mentioned work and provides an introduction to stochastic differential equations with jumps in both theory and application emphasizing the numerical methods needed to solve such equations It presents many new results on higher order methods for scenario and Monte Carlo simulation including implicit predictor corrector extrapolation Markov chain and variance reduction methods stressing the importance of their numerical stability Furthermore it includes chapters on exact simulation estimation and filtering Besides serving as a basic text on quantitative methods it offers ready access to a large number of potential research problems in an area that is widely applicable and rapidly expanding Finance is chosen as the area of application because much of the recent research on stochastic numerical methods has been driven by challenges in quantitative finance Moreover the volume introduces readers to the modern benchmark approach that provides a general framework for modeling in finance and insurance beyond the standard risk neutral approach It requires undergraduate background in mathematical or quantitative methods is accessible to a broad readership including those who are only seeking numerical recipes and includes exercises that help the reader develop a deeper understanding of the underlying mathematics

Stochastic Simulation and Monte Carlo Methods Carl Graham,Denis Talay,2013-07-16 In various scientific and industrial fields stochastic simulations are taking on a new

importance This is due to the increasing power of computers and practitioners aim to simulate more and more complex systems and thus use random parameters as well as random noises to model the parametric uncertainties and the lack of knowledge on the physics of these systems The error analysis of these computations is a highly complex mathematical undertaking Approaching these issues the authors present stochastic numerical methods and prove accurate convergence rate estimates in terms of their numerical parameters number of simulations time discretization steps As a result the book is a self contained and rigorous study of the numerical methods within a theoretical framework After briefly reviewing the basics the authors first introduce fundamental notions in stochastic calculus and continuous time martingale theory then develop the analysis of pure jump Markov processes Poisson processes and stochastic differential equations In particular they review the essential properties of It integrals and prove fundamental results on the probabilistic analysis of parabolic partial differential equations These results in turn provide the basis for developing stochastic numerical methods both from an algorithmic and theoretical point of view The book combines advanced mathematical tools theoretical analysis of stochastic numerical methods and practical issues at a high level so as to provide optimal results on the accuracy of Monte Carlo simulations of stochastic processes It is intended for master and Ph D students in the field of stochastic processes and their numerical applications as well as for physicists biologists economists and other professionals working with stochastic simulations who will benefit from the ability to reliably estimate and control the accuracy of their simulations

Numerical Methods for Stochastic Control Problems in Continuous Time Harold J. Kushner, Paul Dupuis, 2001 The required background is surveyed and there is an extensive development of methods of approximation and computational algorithms The book is written on two levels algorithms and applications and mathematical proofs Thus the ideas should be very accessible to a broad audience

BOOK JACKET Simulation and Numerical Methods for Stochastic Processes Timothy Charles Stutz, 2020 Stochastic processes and randomness are vital features of mathematical modeling in biology Unfortunately analytical results are rarely available for even moderately complex stochastic processes leaving simulation and numerical techniques the main avenues of attack We begin this work by exploring coupling bounds for birth death processes a fundamental type of stochastic process that describes how populations of individuals change over time By forming a coupling between a truncated version of the process and the original unbounded version we are able to compute both moments and transition probabilities for the true process within an acceptable error bound Second we present an algorithm design framework for Interacting Particle Systems IPSs These are complex stochastic processes with wide application to spatial phenomenon across many scientific disciplines Here we describe a method for efficiently sorting particles into classes based off of their type and spatial configuration in such a fashion that reduces the spatial simulation to that of a non spatial well mixed process albeit with a more complicated update step This also allows us to apply a large suite of well developed stochastic simulation algorithms to IPSs with little additional coding cost Third we return to numerical methods this time for

multi type branching processes applied to gene therapy We derive a series of ordinary differential equations that govern the evolution of the probability generating function and provide a straightforward numerical inversion approach to obtain marginalized probability distributions for probabilistic quantities of interest We provide examples of our techniques applied to lentiviral gene therapy and the associated risk of oncogenesis in transplanted hematopoietic stem cell lines Finally we conclude with a chapter on future directions both related to the previous three chapters as well as projects not previously addressed in this work

Stochastic Numerical Methods Raúl Toral, Pere Colet, 2014-06-26 Stochastic Numerical Methods introduces at Master level the numerical methods that use probability or stochastic concepts to analyze random processes The book aims at being rather general and is addressed at students of natural sciences Physics Chemistry Mathematics Biology etc and Engineering but also social sciences Economy Sociology etc where some of the techniques have been used recently to numerically simulate different agent based models Examples included in the book range from phase transitions and critical phenomena including details of data analysis extraction of critical exponents finite size effects etc to population dynamics interfacial growth chemical reactions etc Program listings are integrated in the discussion of numerical algorithms to facilitate their understanding From the contents Review of Probability Concepts Monte Carlo Integration Generation of Uniform and Non uniform Random Numbers Non correlated Values Dynamical Methods Applications to Statistical Mechanics Introduction to Stochastic Processes Numerical Simulation of Ordinary and Partial Stochastic Differential Equations Introduction to Master Equations Numerical Simulations of Master Equations Hybrid Monte Carlo Generation of n Dimensional Correlated Gaussian Variables Collective Algorithms for Spin Systems Histogram Extrapolation Multicanonical Simulations

Numerical Methods for Stochastic Control Problems in Continuous Time Harold Kushner, Paul G. Dupuis, 2012-12-06 This book is concerned with numerical methods for stochastic control and optimal stochastic control problems The random process models of the controlled or uncontrolled stochastic systems are either diffusions or jump diffusions Stochastic control is a very active area of research and new problem formulations and sometimes surprising applications appear regularly We have chosen forms of the models which cover the great bulk of the formulations of the continuous time stochastic control problems which have appeared to date The standard formats are covered but much emphasis is given to the newer and less well known formulations The controlled process might be either stopped or absorbed on leaving a constraint set or upon first hitting a target set or it might be reflected or projected from the boundary of a constraining set In some of the more recent applications of the reflecting boundary problem for example the so called heavy traffic approximation problems the directions of reflection are actually discontinuous In general the control might be representable as a bounded function or it might be of the so called impulsive or singular control types Both the drift and the variance might be controlled The cost functions might be any of the standard types Discounted stopped on first exit from a set finite time optimal stopping average cost per unit time over the infinite time interval and so forth

Stochastic

Processes, Multiscale Modeling, and Numerical Methods for Computational Cellular Biology David

Holcman, 2017-10-04 This book focuses on the modeling and mathematical analysis of stochastic dynamical systems along with their simulations. The collected chapters will review fundamental and current topics and approaches to dynamical systems in cellular biology. This text aims to develop improved mathematical and computational methods with which to study biological processes. At the scale of a single cell, stochasticity becomes important due to low copy numbers of biological molecules such as mRNA and proteins that take part in biochemical reactions driving cellular processes. When trying to describe such biological processes, the traditional deterministic models are often inadequate precisely because of these low copy numbers. This book presents stochastic models which are necessary to account for small particle numbers and extrinsic noise sources. The complexity of these models depends upon whether the biochemical reactions are diffusion limited or reaction limited. In the former case, one needs to adopt the framework of stochastic reaction diffusion models, while in the latter one can describe the processes by adopting the framework of Markov jump processes and stochastic differential equations. Stochastic Processes, Multiscale Modeling and Numerical Methods for Computational Cellular Biology will appeal to graduate students and researchers in the fields of applied mathematics, biophysics, and cellular biology. **Numerical**

Analysis of Systems of Ordinary and Stochastic Differential Equations Sergej S. Artemiev, Tatjana A. Averina, 1997 This book deals with numerical analysis of systems of both ordinary and stochastic differential equations. The first chapter is devoted to numerical solution problems of the Cauchy problem for stiff ordinary differential equation (ODE) systems by Rosenbrock type methods (RTMs). Here, general solutions of consistency equations are obtained which lead to the construction of RTMs from the first to the fourth order. The second chapter deals with statistical simulation problems of the solution of the Cauchy problem for stochastic differential equation (SDE) systems. The mean square convergence theorem is considered as well as Taylor expansions of numerical solutions. Also included are applications of numerical methods of SDE solutions to partial differential equations and to analysis and synthesis problems of automated control of stochastic systems.

Handbook of Stochastic Analysis and Applications D. Kannan, V. Lakshmikantham, 2001-10-23 An introduction to general theories of stochastic processes and modern martingale theory. The volume focuses on consistency, stability, and contractivity under geometric invariance in numerical analysis and discusses problems related to implementation, simulation, variable step size algorithms, and random number generation. **Probability and Stochastic Processes** Ionut Florescu, 2014-11-07 A comprehensive and accessible presentation of probability and stochastic processes with emphasis on key theoretical concepts and real world applications. With a sophisticated approach, Probability and Stochastic Processes successfully balances theory and applications in a pedagogical and accessible format. The book's primary focus is on key theoretical notions in probability to provide a foundation for understanding concepts and examples related to stochastic processes. Organized into two main sections, the book begins by developing probability theory with topical coverage on probability measure, random variables,

integration theory product spaces conditional distribution and conditional expectations and limit theorems The second part explores stochastic processes and related concepts including the Poisson process renewal processes Markov chains semi Markov processes martingales and Brownian motion Featuring a logical combination of traditional and complex theories as well as practices Probability and Stochastic Processes also includes Multiple examples from disciplines such as business mathematical finance and engineering Chapter by chapter exercises and examples to allow readers to test their comprehension of the presented material A rigorous treatment of all probability and stochastic processes concepts An appropriate textbook for probability and stochastic processes courses at the upper undergraduate and graduate level in mathematics business and electrical engineering Probability and Stochastic Processes is also an ideal reference for researchers and practitioners in the fields of mathematics engineering and finance

Topics in Stochastic Processes Robert B. Ash, Melvin F. Gardner, 2014-06-20 Topics in Stochastic Processes covers specific processes that have a definite physical interpretation and that explicit numerical results can be obtained This book contains five chapters and begins with the L2 stochastic processes and the concept of prediction theory The next chapter discusses the principles of ergodic theorem to real analysis Markov chains and information theory Another chapter deals with the sample function behavior of continuous parameter processes This chapter also explores the general properties of Martingales and Markov processes as well as the one dimensional Brownian motion The aim of this chapter is to illustrate those concepts and constructions that are basic in any discussion of continuous parameter processes and to provide insights to more advanced material on Markov processes and potential theory The final chapter demonstrates the use of theory of continuous parameter processes to develop the It stochastic integral This chapter also provides the solution of stochastic differential equations This book will be of great value to mathematicians engineers and physicists

Stochastische dynamische Systeme Josef Honerkamp, 1990 Stochastic dynamic systems often simply called 2complex2 systems are characterized through a many degrees of freedom and b being far away from a state of equilibrium Description and modeling of such systems via stochastic processes play an increasingly important role in applications oriented research in physics chemistry biology and meteorology This book based on lectures given in graduate courses in physics provides the mathematical basis necessary for a comprehensive treatment of complex systems Besides introducing the concepts the author discusses numerical methods to simulate stochastic processes and to fit observed processes to stochastic models

Monte-Carlo Methods and Stochastic Processes Emmanuel Gobet, 2016-09-15 Developed from the author's course at the Ecole Polytechnique Monte Carlo Methods and Stochastic Processes From Linear to Non Linear focuses on the simulation of stochastic processes in continuous time and their link with partial differential equations PDEs It covers linear and nonlinear problems in biology finance geophysics mechanics chemistry and other application areas The text also thoroughly develops the problem of numerical integration and computation of expectation by the Monte Carlo method The book begins with a history of Monte Carlo methods and an overview of three typical Monte

Carlo problems numerical integration and computation of expectation simulation of complex distributions and stochastic optimization The remainder of the text is organized in three parts of progressive difficulty The first part presents basic tools for stochastic simulation and analysis of algorithm convergence The second part describes Monte Carlo methods for the simulation of stochastic differential equations The final part discusses the simulation of non linear dynamics

Encyclopaedia of Mathematics Michiel Hazewinkel, 2013-12-01 This ENCYCLOPAEDIA OF MATHEMATICS aims to be a reference work for all parts of mathematics It is a translation with updates and editorial comments of the Soviet Mathematical Encyclopaedia published by Soviet Encyclopaedia Publishing House in five volumes in 1977 1985 The annotated translation consists of ten volumes including a special index volume There are three kinds of articles in this ENCYCLOPAEDIA First of all there are survey type articles dealing with the various main directions in mathematics where a rather fine subdivision has been used The main requirement for these articles has been that they should give a reasonably complete up to date account of the current state of affairs in these areas and that they should be maximally accessible On the whole these articles should be understandable to mathematics students in their first specialization years to graduates from other mathematical areas and depending on the specific subject to specialists in other domains of science engineers and teachers of mathematics These articles treat their material at a fairly general level and aim to give an idea of the kind of problems techniques and concepts involved in the area in question They also contain background and motivation rather than precise statements of precise theorems with detailed definitions and technical details on how to carry out proofs and constructions The second kind of article of medium length contains more detailed concrete problems results and techniques

Stochastic Processes Kaddour Najim, Enso Ikonen, Ait-Kadi Daoud, 2004-07-01 A stochastic process is a random or conjectural process and this book is concerned with applied probability and statistics Whilst maintaining the mathematical rigour this subject requires it addresses topics of interest to engineers such as problems in modelling control reliability maintenance data analysis and engineering involvement with insurance This book deals with the tools and techniques used in the stochastic process estimation optimisation and recursive logarithms in a form accessible to engineers and which can also be applied to Matlab Amongst the themes covered in the chapters are mathematical expectation arising from increasing information patterns the estimation of probability distribution the treatment of distribution of real random phenomena in engineering economics biology and medicine etc and expectation maximisation The latter part of the book considers optimization algorithms which can be used for example to help in the better utilization of resources and stochastic approximation algorithms which can provide prototype models in many practical applications An engineering approach to applied probabilities and statistics Presents examples related to practical engineering applications such as reliability randomness and use of resources Readers with varying interests and mathematical backgrounds will find this book accessible

Numerical Methods for Stochastic Processes with Applications in Chemical Kinetics and Biology Basil

Bayati,2011

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